The Atomic Weight of Cadmium by an Investigation of Cadmium Chloride and Cadmium Bromide

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THE ATOMIC WEIGHT OF CADMIUM BY AN INVESTIGATION OF CADMIUM CHLORIDE AND CADMIUM BROMIDE*

Among the large number of determinations of the atomic weight of cadmium made since the time of Stromeyer (1818)[1] we can find almost any value between 111.6 and 112.7.[2] A close concordance between the early determinations is hardly to be expected, but among those more recently made and where a better agreement would naturally be looked for practically none is found. The present accepted value of 112.4 is the mean of seven values all above 112.37 while an average of all the values as given by Clarke in his "Constants of Nature" gives us the value of 112.32.[2]

Our interest in the matter was awakened by the work of Perdue and Hulett,[3] wherein a method was devised which makes it possible to determine cadmium electrolytically in such a manner as to avoid inclusions. This was accomplished by means of the mercury cathode, the usual method of procedure being so modified that inclusions were precluded and very exact results obtained. Their analyses of very carefully purified cadmium sulphate crystals gave a percentage of cadmium measurably smaller than that calculated when the accepted atomic weight of cadmium is employed. The atomic weight indicated was 112.30.

In the work by Laird and Hulett,[4] on inclusions in electrolytic deposits, a cadmium coulometer was devised in which it was possible to deposit the cadmium in mercury, in much the same manner as in the Perdue-Hulett method. This, run in series with a silver coulometer, gave 112.31 as the atomic weight of cadmium.

* The work described in this article was made possible by a grant from the Elizabeth Thompson Science Fund, which placed at our disposal some of the special apparatus and materials needed for this investigation, and the authors take pleasure in acknowledging their indebtedness to the Trustees of this Fund.

These two sets of results derived in such a different manner agreed so well that it seemed advisable to extend the investigation so as to include some determinations of cadmium in cadmium chloride and cadmium bromide. These salts have been much used in determining the atomic weight of cadmium; indeed, the accepted value depends largely upon the analyses of these compounds.

Since our results with these salts confirm those obtained by the methods mentioned above, it would seem that the real value for this constant is measurably below the accepted value of 112.4.

Preparation and Purification of Materials

Cadmium.—The sulphate is probably the most easily purified salt of cadmium and for this reason it was used as the starting point of our research. By the method of recrystallization it is possible to get cadmium sulphate in an exceptionally high state of purity, as it is not isomorphous with any known substance.[4]

Kahlbaum's best cadmium sulphate was dissolved in distilled water and the liquid diluted until a 10 percent solution was formed. By treating this solution with hydrogen sulphide so as to precipitate part of the cadmium as cadmium sulphide, digesting the whole on the water bath for twelve hours and filtering, we were able to obtain a solution practically free from other heavy metals present in the original salt. The filtrate was again treated with hydrogen sulphide and in a quantity sufficient to transform almost all of the cadmium into the sulphide. This was filtered off and, after very careful washing, dissolved in nitric acid which had been especially purified by distillation in a quartz distillation apparatus. After removing the free sulphur a calculated excess of sulphuric acid, purified by distillation in a vacuum, was added to the liquid, and the solution placed on the water bath where we permitted it to remain until all of the volatile acid had been expelled. The excess of sulphuric acid was next poured off, the $CdSO_4$ heated to redness in a platinum evaporating dish

covered with a watch glass, transferred to a large flask, covered with distilled water and placed in a stirring apparatus so arranged that the flask could be rotated until a saturated solution was formed. On account of the slow rate of solution this operation sometimes required twelve hours. The solution was finally filtered into a large crystallizing dish and placed in our constant temperature balance room. By proper manipulation the maximum amount of clear crystals could be obtained, the crystals forming by the spontaneous evaporation of the solvent. Such crystals were removed from the mother liquor with ivory forceps and dried in a centrifuge. The process was repeated three times. The resulting cadmium sulphate crystals were large, "water clear," and beautifully formed. The cloudy crystals were dissolved and the crystallization process repeated.

Metallic cadmium was obtained from the pure cadmium sulphate by electrolysis. The apparatus in which the reduction was carried out consisted of a beaker with a filter paper anode cup supported at the top by means of a cork ring. A glass tube also passed through this ring to the bottom of the beaker. Into the end of this tube a platinum wire had been sealed so that only about one-half of a millimeter protruded to serve as a cathode. The anode was a piece of platinum foil about 2×3 cm which was placed inside the anode cup. During the electrolysis the anolyte was allowed to get but slightly acid. This was accomplished by an occasional addition of cadmium carbonate which also served to keep the concentration of cadmium sulphate nearly constant. The cadmium formed under these conditions consisted of very fine crystals which sprouted from the cathode until the bottom of the beaker was completely covered. The current density was kept sufficiently low to permit of the formation of a very compact deposit of cadmium.

The cadmium carbonate used in the above electrolysis was prepared in the following manner: Conductivity water nearly saturated with pure ammonia was treated with pure carbon dioxide in excess and with this reagent cadmium in

the form of $CdCO_3$ was precipitated from a solution of our purified cadmium sulphate. The cadmium carbonate was filtered off, washed, dried and kept in glass-stoppered bottles until used.

After a sufficient amount of cadmium had been obtained, it was removed from the beaker, separated from the electrolyte and washed many times with distilled water. Whether the metal is deposited in a platinum dish or as above described, it is impossible to remove all of the electrolyte by simply washing, as part of it is sure to be included in the crystals. To remove all of the inclusions and get the metal into a hard compact form, we melted the crystals under pure resublimed ammonium chloride. The ammonium chloride acts as a reducing agent and would tend to reduce any oxide or sulphate which might have been dissolved in the metallic cadmium. The ingot thus obtained was clean and bright and could be easily separated from the ammonium chloride which formed a crust on the surface. It was then washed and placed in a hard glass tube so arranged that after the highest possible vacuum had been made over the molten cadmium, it could be distilled from one compartment into another. When most of the cadmium had passed over, the molten distillate was run into a drawn-out end of the tube which was sealed up until used. The cadmium with which our determinations were made was distilled twice by this same process.

Cadmium Chloride.—Part of our pure distilled cadmium was cut into small pieces with a clean pair of steel shears, placed under conductivity water in a Jena glass flask and pure hydrogen chloride gas run in from a generator which will be described later (Fig. 1). After all the cadmium had dissolved, the solution was transferred to a platinum evaporating dish, covered with a watch glass and evaporated to dryness on a water bath. The salt was dried as far as possible on the water bath, and then put into an oven and heated to about 200° C for several hours. It was finally broken up, removed with a platinum spatula and preserved in a glass-stoppered bottle.

Method of Analysis.—The general method of melting cadmium chloride under pure dry hydrogen chloride was the same as that used by Baxter and Hines[5] in their work on the atomic weight of cadmium in 1905. The hydrogen chloride was generated and used in the following apparatus: in the large two-liter flask (*a*) (Fig. 1) was placed the purest grade of Baker's hydrochloric acid. The hydrogen chloride was driven from this by heating the flask gently. The gas was dried by first passing it through the condenser placed in the Dewar tube (*c*) and surrounded by the freezing mixture (*b*). The freezing mixture was made by mixing finely ground ice

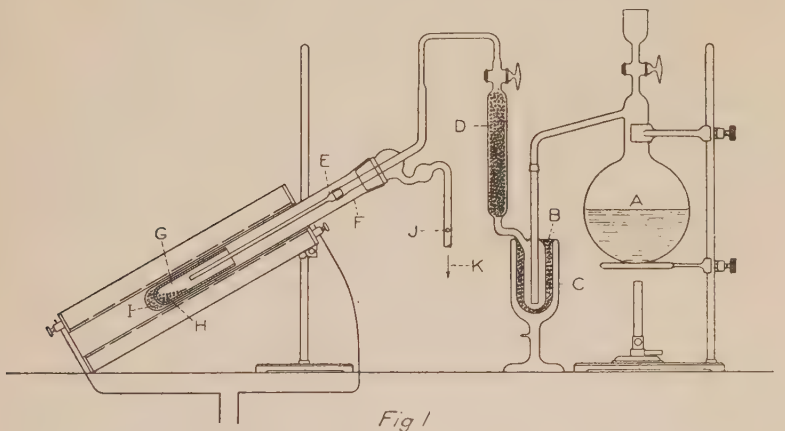


Fig 1

and ground crystallized calcium chloride. The temperature was kept at about —20° C by this mixture and practically all of the water was removed. The gas then passed through the calcium chloride tube (*d*) and from there into the fusion apparatus (*f*). This consisted of a large, hard, glass tube provided with a very carefully ground glass stopper. The stopper was similar to that of a Drexel wash bottle and the tube passing through was ground on to a small quartz tube shown at (*e*) which conducted the hydrogen chloride over the cadmium chloride in the quartz crucible (*g*). The excess of gas then passed out through the tube (*k*) which was connected with a suction pump. The small opening (*j*) allowed air to enter,

so the pressure in the apparatus was not reduced. To prevent the tube from breaking on cooling from a high to a low temperature a wad of asbestos was placed at (*i*). The tube was heated in a platinum resistance furnace with a 110 volt alternating current. By means of an adjustable resistance the temperature could be regulated very well. The connection between the fusion tube and the generator was always sealed before a fusion was made so that all joints were of glass or ground together.

Crucible.—Our first idea was to use a platinum Smith crucible, but we soon found that platinum would not do, as the molten cadmium chloride at that high temperature dissolves quite an appreciable amount of this metal. Baxter and Hines[5] in their work made corrections for the dissolved platinum. However, the large amount lost by our crucible at each heating made it necessary for us to look for some other material. Table I gives the loss in weight of the crucible during four heatings.

TABLE I

	Weight before heating Grams	Weight after Grams	Loss in weight Gram
1	24.82894	24.82888	0.00006
2	24.82888	24.82592	0.00296
3	24.82592	24.82431	0.00161
4	24.82349	24.82349	0.00082

From these figures we see that the total loss during four fusions was somewhat over 5 mg. It seemed that platinum would be useless for this work, so we tried quartz. At first the special quartz crucible we used lost weight, and sometimes the loss was quite appreciable. The loss, however, did not take place when we washed the crucible carefully and took special care that our hands did not afterwards come in contact with its surface. Our crucible was a closed quartz tube about 8 cm long, with a platinum cap very accurately ground on the top. A cross-section of the tube is shown at (*g*) (Fig. 1).

The next step was to find an exact and delicate test for

cadmium in an acid solution such as would result upon the evaporation of our electrolyte after electrolysis. Potassium ferrocyanide was first tried and, in a neutral solution, it worked very well. Cadmium may be detected by this means when the concentration is as small as 0.008 mg per cc. However, when this test was applied to our evaporated electrolyte it was found to be useless. The solution usually turned dark blue and sometimes gave a precipitate even when there was no cadmium present. This was proved by running several blank tests. It is possible that persulphuric acid ($H_2S_2O_8$) was formed in the electrolyte, and this produced Prussian blue by its action on the ferrocyanide. We next made determinations by treating small concentrations of cadmium sulphate with hydrogen sulphide gas. The tests were carried out in tubes of the Nessler form but holding, when filled, only about 2 cc of solution. Blanks were run at the same time in similar tubes and under like conditions. We tried the following concentrations:

0.0843 mg Cd to 1 cc water
0.042 mg Cd to 1 cc water
0.021 mg Cd to 1 cc water
0.0084 mg Cd to 1 cc water

The cadmium in the first three could be detected at once, while the liquid in the fourth was slightly colored after standing a day. Since the blank used for comparison in the latter case was treated in the same manner, and allowed to stand the same length of time, the difference in color must have been due to cadmium sulphide and not to free sulphur. We evaporated all of our electrolytes to 1 cc, and tested each in this manner so there was little chance for any cadmium to escape deposition without being detected.

All of our weighings were made in an especially designed balance room. The Borda method of substitution was used, and the readings of the pointer taken by means of telescope. The temperature of the room was always under control, being kept practically constant. The moisture content of the room was also under control. The air which entered the room was

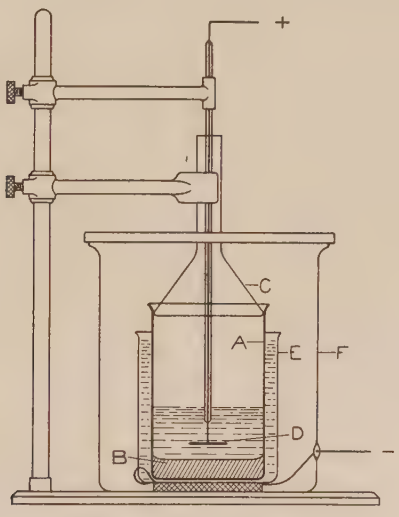
forced through a large, upright cylinder of calcium chloride by means of an electric fan. In all our weighings the pressure, temperature and humidity were recorded, so at any time we could calculate the weight of 1 cc of air. The average weight was 1.17 mg per cc and the variations from this were so slight as to be negligible. The object was always allowed to stand inside the balance room at least one hour before a weighing was attempted, and after placing the object on the balance pan we always waited at least ten minutes for the temperature to become constant before the readings were taken. All of our weights were very carefully calibrated.

The vacuum correction was calculated from the density of cadmium chloride, found by Baxter and Hines[5] to be 4.049. We found the correction to be +0.153 mg for each gram of cadmium chloride weighed. The correction for the cadmium dissolved in mercury was taken from the work of Perdue and Hulett who found it to be —0.014 mg for each gram of cadmium dissolved in mercury.[6]

The problem of electrolyzing a chloride solution in a crucible such as we proposed to use was a very difficult one to solve. The chlorine liberated at the anode acted on the mercury in such a manner that the electrolyte as well as the mercury was blackened. To prevent this we tried electrolysis in a vacuum, also inclosing our anode in a glass cup. As none of these methods were successful we undertook to change the chloride to the sulphate before electrolysis. This plan worked very satisfactorily. A solution of the cadmium chloride in water was transferred to a platinum evaporating dish which was covered with two watch glasses. One was small enough to be placed in the dish with the concave surface down. A small hole was drilled through its center for the escape of vapors. The other was larger and placed over the evaporating dish with the concave surface up. Two holes were drilled through this glass, one on each side of the center. With these watch glasses over the solution it was impossible for any to escape by spattering. However, a free passage for the water vapor was provided for and the evaporation proceeded at a fair

rate. To the cadmium chloride was added a slight excess of the calculated amount of sulphuric acid and the whole evaporated to dryness on the water bath. It was then transferred to a hot air oven and heated slowly to 220° C. After the sulphuric acid had fumed for some time it was cooled and transferred to the crucible for electrolysis.

The electrolysis apparatus consisted of a specially designed platinum crucible of about 100 cc capacity. The diagram in Fig. 2 shows the arrangement of this crucible with the rest



—Fig. 2—

of the apparatus. Fitting in the crucible (*a*) is the carefully ground glass funnel (*c*), which served as a cover and allowed the anode (*d*) to pass through the stem. The crucible was amalgamated with mercury by heating a small amount in the bottom to its boiling point and allowing the vapor to condense on the sides up to about 1 cm from the top, so that by rotating the crucible on its side a continuous film of mercury would wet its sides and bottom. It was then placed in the small glass cup (*e*) and surrounded with distilled water, the cup resting in a larger glass jar (*f*), and the space between being filled with ice water. A split glass plate covered the top of

the jar so that nothing but the funnel stem protruded. The electrical connections were made by means of a platinum wire through the glass jars to the crucible inside. All the mercury used in these determinations was distilled three times, and was exceptionally pure. After the crucible had been amalgamated, and before it was weighed, it was washed on the outside, first with dilute nitric acid and then with distilled water. Afterwards it was placed in a desiccator and allowed to dry.

The actual operation carried out during each determination was as follows: A definite amount of cadmium chloride was placed in the quartz crucible (after it had been weighed) and the charged crucible introduced into the fusion apparatus. After this apparatus had been sealed to the hydrogen chloride generator it was heated in the furnace to about 600° C and at the same time a slow stream of dry hydrogen chloride was passed over the salt. When melted and still in the molten state, the inlet tube was sealed off above the apparatus, and the outlet tube sealed off below. The tube was then taken from the furnace and laid upon its side on an asbestos mat. This allowed the molten cadmium chloride to cool on the side of the crucible so that the solid mass was easily removed when desired. After it had cooled to the room temperature the tube was cut open under a stream of pure, dry air which at once filled the partial vacuum formed. With a stream of pure, dry air flowing over the top of the tube the stopper was removed and the platinum cap quickly placed on the crucible by means of a glass rod. The crucible containing cadmium chloride, hydrogen chloride and dry air was then removed and as quickly as possible wiped and placed in a vacuum desiccator which was evacuated to a pressure of about 0.1 mm. After the desiccator had remained in the balance room for several hours, air was allowed to enter through a calcium chloride tube and the weighing was made. The calcium chloride was then removed from the crucible and placed in a covered platinum dish. The crucible was well washed with water and set aside to be tested ater for cadmium. To the cadmium chloride solution a slight excess of pure sulphuric acid was

added, the liquid evaporated and then heated to fuming. The cadmium sulphate formed in this way consisted of small, anhydrous crystals which were easily removed with a platinum spatula and placed in the tared crucible for electrolysis. The watch glasses as well as the quartz crucible were washed with a small amount of water and the washings added to the crucible. Finally they were washed with a large amount of water and this was evaporated to about 1 cc and the solution tested for cadmium. None was ever found, however, and during the last of our determinations the evaporated wash water was added to the electrolyte in the crucible.

The solution was then electrolyzed for about seven hours, starting the current at about 200 milliamperes and then bringing it up to about 500 which current strength was maintained during the greater part of the run. Before the electrolyte was removed the current was run up to about one ampere for one-half hour. All this time the temperature of the crucible was never allowed to rise above room temperature. After the run was completed the electrolyte was drawn out by means of a pipette while water was simultaneously run in. This was accomplished in such a way that the current was never interrupted or the mercury agitated. After the ammeter showed no current to be passing, the rest of the water was removed and the crucible transferred to a vacuum desiccator which was evacuated with an air pump. In a very short time the crucible was ready to weigh.

The results we obtained are shown in Table II.

The probable error for a single determination is ±0.004 percent, while the probable error for the mean is ±0.001 percent.

The question of any error in the method or losses due to changing the chloride to sulphate was regarded as most important, and direct information was obtained on these points by the following experiments and blank determinations:

The pure metallic cadmium was cut into small pieces and a definite amount weighed out. This was placed in a platinum evaporating dish and covered in the same manner

TABLE II—ATOMIC-WEIGHT DETERMINATIONS ON $CdCl_2$

Number of determination	Weight of $CdCl_2$ Grams	Vacuum correction Gram	Mass of $CdCl_2$ Grams	Weight of Cd Grams	Vacuum correction Gram	Mass of Cd Grams	Percent of Cd	Atomic weight of Cd
1	4.10058	+0.00061	4.10119	2.51430	—0.00003	2.51427	61.306	112.36
2	4.47084	+0.00067	4.47151	2.74087	—0.00003	2.74084	61.295	112.31
3	5.66376	+0.00076	5.66452	3.47184	—0.00004	3.47180	61.290	112.28
*4	5.99200	+0.00091	5.99291	3.67216	—0.00005	3.67211	61.274	112.20
5	6.52811	+0.00099	6.52910	4.00224	—0.00005	4.00219	61.298	112.32
6	4.87342	+0.00073	4.87415	2.98789	—0.00004	2.98785	61.300	112.33
7	4.88350	+0.00073	4.88423	2.99388	—0.00004	2.99384	61.296	112.31
						Average	61.297 ±0.001	112.32 ±0.01

Atomic weight of Cl taken as 35.458

* Determination No. 4 was excluded in the final average as the cadmium deposited in flaky crystals on the side of the crucible and it is probable that some was lost during the washing.

as our cadmium chloride. It was then treated with distilled hydrochloric acid, evaporated to dryness, and, after dilution, the necessary amount of sulphuric acid was added. After evaporating and heating the liquid in a manner similar to that employed in the case of our cadmium chloride, the sulphate was dissolved, the solution electrolyzed and the deposit weighed. As all of the operations were carried out as nearly as possible as they were with our chloride the error of all the manipulations would be ascertained. Our blank experiments are shown in Table III.

TABLE III

No.	Weight before Grams Cd	Gain in weight of the crucible Grams Cd	Difference Gram
1	2.23578	2.23552	—0.00026
2	2.11198	2.11225	+0.00027
3	2.79347	2.79331	—0.00016
4	2.02396	2.02379	—0.00017
5	1.55217	1.55232	+0.00015

It appears from these experiments that we can start with a weighed piece of our pure cadmium, change it to the chloride, then to the sulphate, deposit it in mercury and get the weight of the original cadmium and all of the errors combined are not greater than one part in 10000 for the probable error of a single determination.

Cadmium Bromide

Our next investigation was on the bromide of cadmium. This is a beautiful, white salt which, since it can be easily purified, is exceptionally well suited for atomic-weight determinations. The method for the determination of the cadmium in this salt was very similar to the one used in the case of the chloride; modifications were made only when the nature of the salt made this necessary.

Purification of Materials

Cadmium.—The cadmium employed in all of these determinations was a sample of that used by us for the preparation of the chloride.

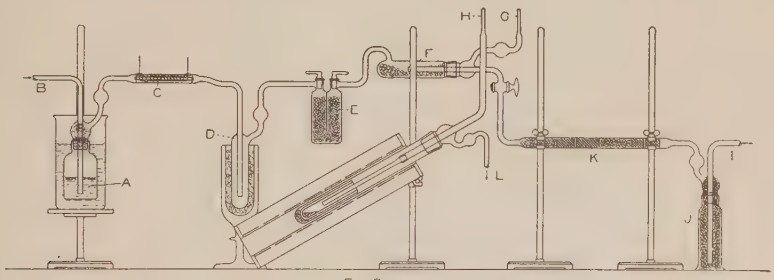
Bromine.—The best grade of Kahlbaum's bromine was purified in much the same manner as that described by Weber[7] in his work on the atomic weight of bromine. It was distilled three times from solution of potassium bromide. The potassium bromide was made by treating pure potassium oxalate with bromine and crystallizing the potassium bromide thus formed. After the distillation the bromine was cooled until most of it had crystallized. The mother liquor was rejected. The crystals were then allowed to melt somewhat and the liquid bromine poured off. The remaining crystals were melted again and the process repeated until bromine with a melting point of —7.2° C was obtained. By this treatment Weber was able to purify the bromine so that the presence of chlorine or iodine could not be detected by any known reagents. This pure bromine was used in the preparation of our cadmium bromide, as well as for the preparation of the hydrogen bromide under which the cadmium bromide was melted.

Hydrogen.—The hydrogen was prepared by the electrolysis of a solution of pure potassium hydroxide from which the carbonates had been precipitated with barium hydroxide. After the generator had been started it was allowed to run for several days before we connected it with our hydrogen bromide apparatus.

Preparation of Cadmium Bromide.—For the preparation of this salt a portion of our purest metallic cadmium was cut into small pieces with a clean chisel. This was placed in a quartz evaporating dish and treated with our purified bromine under conductivity water slightly acidified with hydrobromic acid. Our first lot was treated under ordinary distilled water and the resulting cadmium bromide gave tests for organic matter. This lot was discarded and the next lot was dissolved in our best conductivity water which showed no trace of organic matter whatever. The bromine was added to the cadmium in small portions until most of the metal had gone into solution. The solution was filtered through especially purified asbestos and evaporated almost to the saturation

point of the solution. The quartz dish with its contents was then placed in our constant temperature room and the salt allowed to crystallize by spontaneous evaporation of the liquid. It was possible to get very clear crystals, which we removed and dried in a platinum dish in a vacuum desiccator. The salt was preserved in glass-stoppered bottles until used.

This salt like the chloride was fused in an atmosphere of the corresponding acid before the determination was made. Here we used a mixture of nitrogen and hydrobromic acid gas, instead of the pure acid gas as we did in the case of the chloride. Fig. 3 gives an idea of the apparatus we used for this purpose.



—Fig 3—

Pure hydrogen from our electrolytic generator was bubbled through the pure bromine (*a*) in the Drexel wash bottle. This was arranged as shown in the figure with a water bath around it so that a temperature of 60° C could be maintained. The mixture of hydrogen and bromine vapor passed over the glowing platinum spiral (*c*), made by winding a platinum wire on a small porcelain tube. The ends were gold-soldered to heavy platinum leads, and these were sealed through the sides of the glass tube. Combination of the hydrogen and bromine took place at the point (*c*) and burned with a bright flame. The excess of bromine (we always kept an excess of bromine in the mixture) was condensed in (*d*) which was surrounded with ice. Only a trace of bromine remained in the gas after passing it through this cooling mixture. The gas was then dried by passing through the bottle (*e*) which contained pure calcium bromide. It was finally dried by passing through

the drying tube (*f*) which contained phosphorus pentoxide and which served as a mixing chamber for the nitrogen and hydrogen bromide. This gas mixture was conducted over the cadmium bromide by means of a glass tube sealed to the fusion apparatus at the point (*h*). The fusion apparatus is shown more in detail in Fig. I. The nitrogen which entered the apparatus at (*i*) was made by removing the oxygen from the air by a method devised by Hulett.[8] It was stored in a large carboy and forced out under pressure by displacement with water. The preliminary drying was effected in the cadmium chloride tube (*j*). After passing over heated copper and copper oxide the gas was further dried with soda lime, and finally in the mixing chamber, by phosphorus pentoxide. All connections were sealed and the stopcocks in cases where it was absolutely necessary contained but a very small amount of "Vacuum Hahnfett." The fusion tube containing the cadmium bromide was always sealed to the apparatus at (*h*), and, after the cadmium had melted, it was sealed off and the outlet to the tube also sealed.

Treated in the same manner as the cadmium chloride, the tube was removed from the furnace and after cooling cut open and pure, dry air allowed to enter the partial vacuum produced by the cooling. The quartz crucible was then quickly covered with a platinum cap and after wiping placed in a vacuum desiccator which was evacuated at once. After standing in the balance room for some time dry air was let into the desiccator and the tube weighed. This operation was carried out in exactly the same manner as described under the chloride determinations.

To change the bromide to the sulphate we transferred it to the platinum evaporating dish, covered it with a watch glass and treated it with a few drops of pure, distilled nitric acid. The bromine thus liberated was driven off with gentle heat and the operation repeated until all of the bromide had been changed to the nitrate. This solution was then evaporated on the water bath to dryness. A small amount of water was then added and the calculated amount of sulphuric acid

also added after the salt had gone into solution. This was evaporated to dryness and electrolyzed in the usual manner. All of the precautions against loss which we used with the chloride were also used with this salt. As there might be some question about platinum being dissolved from the evaporating dish by the free bromine, the last three of our determinations were made in a Jena glass flask, provided with a ground glass stopper arranged with an outlet tube containing a series of bulbs to prevent loss by spattering. This was heated over a free flame and after all of the bromine had been driven off, the solution was transferred to the evaporating dish and treated with sulphuric acid as before. The results seem to indicate that no appreciable amount of platinum could have been dissolved in the first case.

Blank tests were made in a manner similar to that described under cadmium chloride. All of these results are shown in Table III.

The results for the cadmium bromide determinations are shown in Table IV.

The probable error for a single determination is ± 0.003 percent, while the probable error for the mean is ± 0.001 percent.

From our chloride results we get as an average 112.32 for the atomic weight of cadmium and from the bromide an average of 112.26. The average of these two is 112.29, which is in excellent agreement with the results of Perdue and Hulett, and those obtained by Laird and Hulett. These results go to prove that the atomic weight of cadmium is nearer 112.3 than the present accepted value 112.4.

We attempted to get more evidence on the atomic weight of cadmium by making determinations on cadmium oxide but it seemed to be a difficult operation to prepare this substance in a high state of purity. Our idea of burning pure cadmium vapor in carefully purified oxygen worked out very satisfactorily, and we constructed an apparatus with which we were able to prepare large quantities of the oxide in a very short time, but the resulting oxide was found to contain a trace of

TABLE IV—ATOMIC-WEIGHT DETERMINATIONS ON $CdBr_2$

Number of determination	Weight of $CdBr_2$ Grams	Vacuum correction Gram	Mass of $CdBr_2$ Grams	Weight of Cd Grams	Vacuum correction Gram	Mass of Cd Grams	Percent of Cd	Atomic weight of Cd
1	4.95493	+0.00045	4.95538	2.04471	—0.00003	2.04468	41.261	112.28
2	4.15765	+0.00036	4.15801	1.71575	—0.00002	1.71573	41.263	112.29
3	5.31224	+0.00048	5.31272	2.19186	—0.00003	2.19183	41.256	112.26
4	4.55504	+0.00040	4.55544	1.87943	—0.00003	1.87940	41.256	112.26
5	4.31487	+0.00038	4.31525	1.78015	—0.00002	1.78013	41.252	112.24
6	5.69595	+0.00051	5.69646	2.34986	—0.00003	2.34983	41.251	112.23
7	4.47708	+0.00040	4.47748	1.84757	—0.00003	1.84754	41.263	112.29
8	5.36228	+0.00048	5.36276	2.21231	—0.00003	2.21228	41.253	112.24
						Average	41.257	112.26
							±0.001	±0.005

Atomic weight of Br taken as 79.92

the peroxide. This was also noticed by Sidot,[9] who made cadmium oxide by burning cadmium in the air. As this impurity was not easily removed we found it necessary to devise some other method for preparing the compound.

Laboratory of Physical Chemistry,
Princeton University,
April, 1913

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